Flight Qualified Laser Radar for Spacecraft Guidance Application

C.C.Liebe, A.Abramovici, R.L.Bunker, R. Calvet, J.Chapsky, C.Chu, D.Clouse, J.Dillon, D.Franzen, R.Hausmann, H.Hemmati, R.Kornfeld, C.I.Kwa, R.Miseroy, S.Mobasser, M.Newell, C. Padgett, T.Roberts, G.Spiers, D.Tratt, Z. Warfield, M.Wright, R.Bartman

Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Dr., Pasadena CA 91109-8099

A flight qualified Laser Mapper (LAMP) is currently being developed at the Jet Propulsion Laboratory, California Institute of Technology under funding from the Mars technology program. LAMP is an active optical instrument that is able to determine the distance to objects in the instrument field of view - basically the same functionality as a radar but using time of flight of a laser beam. LAMP will be used as guidance sensor in different applications.

Previous landings on Mars have utilized either radar controlled retro rockets or airbags and landed on comparatively flat terrains with minimal hazards. Future missions require landings in more geologically interesting areas of Mars. Therefore, a sensor that is able to guide the spacecraft away from large boulders and hazards on the surface in the final stage of the decent is required. The LAMP instrument can make topographical maps of the surface in the final stages of the decent and guide the Lander to a safe landing spot.

Another future goal of the Mars program is to return a sample of Mars soil to Earth for further analysis. The way that this is envisioned is to send a spacecraft to Mars that collects a soil sample and puts it into a grapefruit sized container covered with retro-reflectors and launches the container into orbit around Mars. Another spacecraft will then come and snatch the orbiting container and return it to Earth. LAMP will also be used as the guidance sensor for the container capture phase of the mission.

LAMP operates by emitting high power ultra short laser pulses, which bounce off an internal gimbaled mirror that determines the azimuth and elevation of the outgoing beam. When the laser pulses hit a target surface a small amount of the light is reflected back to the instrument. The returned laser pulse bounces off the internal mirror and is collected by a telescope. On the way out, the laser actuated trigger starts a counter that is stopped by the return pulse. The counter value (time of flight) is proportional to the distance to the object.

LAMP is based on a passively Q-switched Nd-YAG microchip laser. The repetition rate is approximately 10 KHz and the pulse energy is approximately 10 mJ. The gimbaled mirror provides a field-of-regard of 12 by 15 degrees, and under software control it is capable of scanning the entire field-of-regard (100 x 100 samples) in 1 second. The receive telescope has a 5 cm aperture with an Avalanche Photo-Diode (APD) to detect weak signals. A Si-PIN diode is used to detect strong signals. The timing chip has a resolution of 400 ps. The detection range for LAMP is a couple of kilometers for extended diffuse targets and several kilometers if the target is equipped with retro-reflectors. The mass is ~5 kg and the power consumption is ~35 Watts.

This paper will describe the LAMP instrument and its performance obtained in field-testing.